## 2. Channel Conditions and Riparian Habitat

In this section we discuss rivers and non-river water types separately. Rivers include their main channel, side channels, and alcoves. The non-river waters include streams (both natural and excavated), drainage channels, sloughs, gravel pit ponds, other excavated ponds, and natural ponds. Different techniques were used to evaluate channel and riparian vegetation characteristics for the two groups.

Rivers were evaluated by dividing the MECT rivers into reaches and using aerial photographs and field visits to derive information. The information is summarized by reaches or groups of reaches. We divided the river into 28 reaches that ranged from 0.4 mile to 2.2 miles in length (average of 1.3 miles). A reach was delineated such that it encompassed a unique channel condition. Segments of relatively straight channel with few side channels or alcoves were segregated from segments with meandering channels with many side channels or alcoves (Map 10a). Alcoves are like side channels except they have no upstream surface connection to the main channel during lower flows. Reaches also ended and began at river confluences.

Non-river waters were evaluated by dividing into many short reaches (more than 1000) and characteristics were assigned to each reach using existing GIS layers, field visits, aerial photographs, and maps. A reach is a length of waterway or perimeter of pond with uniform characteristics. Field visits were made to the one-third of segments where we could get access. Characteristics of the other two-thirds of segments were estimated using information on upstream and downstream field-visited reaches and aerial photographs. A majority of those segments not visited in the field were minor waterways such as drainage channels.

### *2.1 Rivers*

The MECT study area is dominated by the channel and floodplains of four converging rivers, including 18.0 miles of the lower McKenzie River, 12.5 miles of the Willamette River, 7.0 miles of the lower Middle Fork Willamette River, and 4.6 miles of the lower Coast Fork Willamette River. Included are over 13 miles of side channels (excluding man-made or highly altered natural features such as the Springfield Mill Race, Eugene Mill Race, Alton Baker Canoe Canal, and the Delta Ponds complex) and 4 miles of alcoves along with the 42 miles of main channel (Table 2, Map 4).

**<u>Table 2</u>. Current channel characteristics by segment for rivers within the study area.** Determined by measuring from 2000 aerial photographs. See Maps 6-12 for illustration of river reaches.

| Segment | Main channel (miles) | Side channels (miles) | Alcoves (miles) |
|---|---|---|---|
| Lower Willamette (reach 2) | 0.8 | 0.8 | 0.3 |
| McKenzie (reaches 3-14) | 18.0 | 7.9 | 2.2 |
| Upper Willamette (reaches 15-20) | 11.7 | 2.7 | 0.7 |
| Middle Fork Will. (reaches 21-25) | 7.0 | 1.2 | 0.8 |
| Coast Fork Will. (reaches 26-28) | 4.6 | 0.6 | 0.0 |
| Total (2-28) | 42.1 | 13.2 | 4.0 |

### 2.1.1 Large wood in rivers

Large wood forms complex features within channels that are preferred habitat of Chinook salmon and other fish. The regular flow of the water is disrupted by large wood in the channel and creates deep pools, sorted gravels, nooks and crannies for fish to rest in slow water and then dart into fast water areas to retrieve food, and it provides cover from predators. Large wood is also a favored substrate by some aquatic insects and therefore is a boost to the food base of fish. In addition, when large wood is present in large quantities, it can alter the overall geomorphology of the river by initiating island and side channel development. These features provide specialized habitat for fish in the form of low-velocity water and gravel deposits favorable for aquatic insects.

The hydrology, geometry, and banks of rivers in the study area have been altered during the last 150 years to increase use of the river and adjacent land. One of the earliest changes began in the late 1800s when a large number of snags and log jams were removed from the channel to promote navigation and the driving of commercial logs down the river to sawmills in Eugene, Coburg, and downstream. Between 1870 and 1911, nearly 400 logs per mile of river were snagged out of the Willamette River from Eugene to Albany (Sedell and Froggatt 1984). Removing log jams from a river influences the channel in several ways: 1) the channel becomes narrower and straighter with fewer side channels and meanders, 2) the bedload of the river becomes more coarse due to the higher velocity water resulting from a straighter and less-obstructed channel, and 3) the reduced meandering decreases the amount of finer material that can be incorporated into the channel bottom when banks are undercut.

Few logs are found in the rivers today. For example, the lower McKenzie River (downstream of Hendricks Bridge) now averages only 1.2 single logs per mile and 0.15 log jams per mile (Alsea Geospatial et al. 2001). The current scarcity is due to continued intentional removal of wood (often for firewood), trapping of logs at the reservoirs, reduced channel meandering that would normally undercut streamside trees, and reduced numbers of older trees growing along the river. Much of the loss of older streamside trees has occurred in recent decades. In the lower McKenzie River, the percentage of main channel river bank supporting trees greater than 40 years old decreased from 37% to 12% between 1944 and 2000 (Alsea Geospatial et al. 2001).

### 2.1.2 River peak flows

The hydrology of the rivers, and consequently their geometry, were altered significantly following construction of upstream flood control reservoirs from 1942 to 1968. Current values for the 100-year instantaneous peak flow range from 62% of normal for the Coast Fork Willamette River to 22% of normal for the Middle Fork Willamette River (Figure 5). To put this in perspective, the February, 1996 flood on the McKenzie River was the highest on record since completion of the two upstream reservoirs. Yet, flows greater than the 1996 flood occurred about four times per decade prior to dam construction.

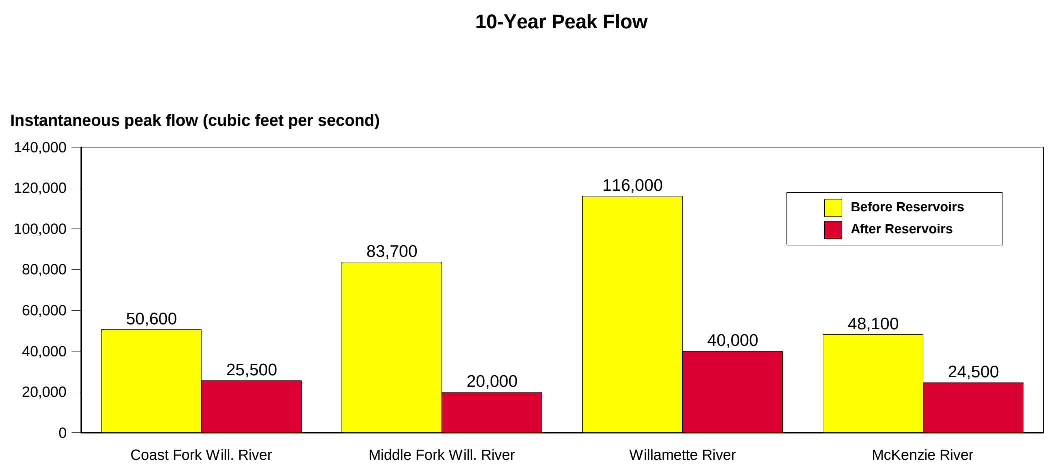
Reducing peak flows of a river limits its ability to meander, create new side channels, ponds, and alcoves, and keep off-channel features from readily filling with fine sediments (Miller et al. 1995, Van Steeter and Pitlick 1998, Friedman et al. 1998). Consequently, the river becomes straighter, the channel less complex, and the substrate coarser. A river without flood storage reservoirs and riprapped banks is more capable of meandering across its flood plain, entraining smaller-sized sediments stored in the banks, and depositing them on the inside of downstream bends or on top of low riverside terraces.

Dams are capable of trapping gravel and fine sediments in their reservoirs. However, observations of the reservoirs when they are empty reveal that, except for limited sediment wedges at the heads of the reservoirs where rivers enter, there is little sedimentation within the reservoirs. Stumps cut at the time of reservoir establishment (35 to 50 years ago) are still readily visible at the reservoir’s bottom surfaces. Because most of the Willamette basin reservoirs are emptied during the winter (except during major runoff events), river water is entrenched along the axis of the reservoir and is therefore capable of transporting much of its load of suspended sediment and bedload downstream through and beyond the dam.

### 2.1.3 Gravel extraction

Another major change to the rivers was the extraction of gravel from channels, and later, from adjacent flood plains. Aerial photographs from 1944 show extensive mining of gravel within the main channel of the Willamette River upstream of Skinner Butte and downstream of the current Interstate 5 bridge (reach 18, Map 10a). At that time, gravel bars lined 44% of the riverbanks. Currently, only 2% of the riverbank length in reach 18 is bordered by gravel bars. Beginning in the late 1960s, extensive gravel mining within channels also occurred at the mouth of the McKenzie River (reaches 3-4), within the Willamette River immediately upstream of the McKenzie River confluence (reach 15), and at the mouth of the Coast Fork Willamette River (reach 26).

The mouth of the McKenzie River once occupied an active flood plain between one-half to one mile wide with two major channels and numerous small side channels (Andrus et al. 2000). The river has since been forced into the northern of the two major channels and the remainder of the delta to the south has been diked and is currently being mined for gravel. Prior to mining, the lower Coast Fork Willamette River (reach 21 and 26) meandered across a wide flood plain and paralleled the Middle Fork Willamette River for several miles. Gravel extraction (sometime after 1944) along its main course left a wide and deep trench that the river currently occupies.



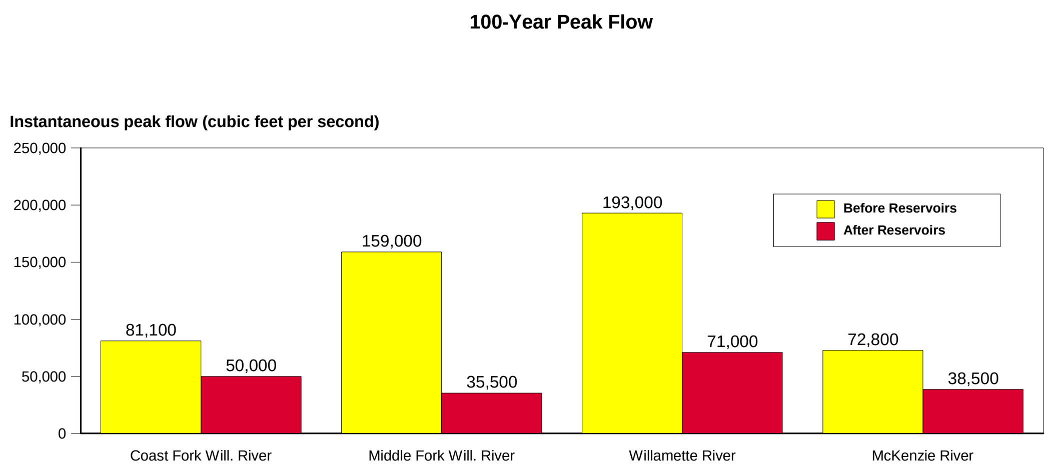




**Figure 5. Changes in 10-year and 100-year peak flows due to upstream reservoirs for rivers in the study area.** Gauging sites for the various rivers include: Goshen for the Coast Fork Willamette River, Jasper for the Middle Fork Willamette River, Springfield for the Willamette River, and Vida for the McKenzie River. Information provided by U.S. Corps of Engineers in 2002 (unpublished data).

### 2.1.4 Riprap

Over the last six decades, some river banks in the study area have been lined with riprap (large angular rock overlying the banks about 3 to 5 feet deep) to prevent channel meandering. Most riprap is placed on the outside banks of the river where the water is fastest. Overall, 17 percent of river banks in the study area are riprapped (Table 3). Riprap is most common in the McKenzie River downstream of the Interstate Highway 5 bridge, upper Willamette River (between the McKenzie River confluence and the Coast Fork Willamette River confluence) and in the Middle Fork Willamette River (Figure 6). Only three reaches have no riprapped banks. The seven reaches with the highest density of riprap are summarized in Table 4.

While riprap is effective at preventing river meandering and protecting property, it has some biological drawbacks. First, a number of native fish tend to avoid riprap banks. The reason is unknown, but may include a lack of low-velocity zones for feeding and the deep water that invariably develops along riprapped banks. Second, riprap tends to simplify the river channel and prevent it from forming diverse habitat features such as side channels, alcoves, and gravel bars.

**Table 3. Length of riprapped main channel relative to total bank length in year 2000.** Riprap along rivers was inventoried in the field by boat throughout the study area.

| | Riprapped bank length (miles) | Total bank length* (miles) | % bank with riprap |
|---|---|---|---|
| Overall (reaches 2-28) | 14.5 | 84.2 | 17 |
| Lower Willamette River (reach 2) | 0.0 | 1.6 | 0 |
| McKenzie River (reaches 3-14) | 4.6 | 36.1 | 12 |
| Upper Willamette River (reaches 15-21) | 5.2 | 23.3 | 22 |
| Middle Fork Willamette River (reaches 22-25) | 3.4 | 14.0 | 24 |
| Coast Fork Willamette River (reaches 26-28) | 1.4 | 9.2 | 15 |

* Assumed to be twice the thalweg length.

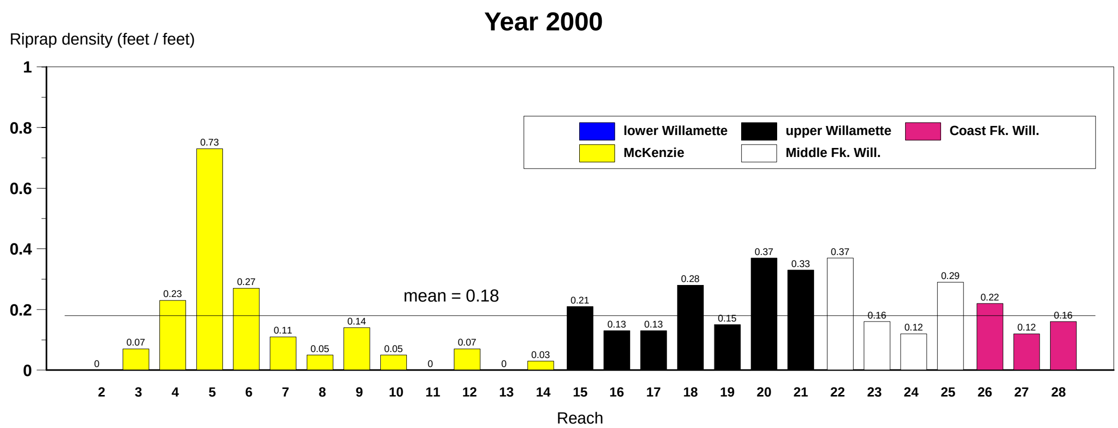



**Figure 6. Riprap density (feet of riprapped bank per feet of river total river bank in a reach) for the 27 river reaches in the MECT study area.**

**Table 4. Seven highest ranking river reaches for riprap density in year 2000.**

| Ranking | Reach | River | Year 2000 length (feet/feet)* |
|---|---|---|---|
| 1 | 5 | McKenzie | 0.73 |
| 2 | 22 | Middle Fork Will. | 0.37 |
| 3 | 20 | Upper Willamette | 0.37 |
| 4 | 21 | Upper Willamette | 0.31 |
| 5 | 25 | Middle Fork Will. | 0.29 |
| 6 | 18 | Upper Willamette | 0.28 |
| 7 | 6 | McKenzie | 0.27 |

***** Feet of riprapped bank per feet of river total river bank in a reach.

### 2.1.5 River geomorphology

River reach boundaries were marked on year 2000 aerial photographs and replicated on the pre-reservoir 1944 aerial photographs. The 1944 photos were the oldest located that had sufficient quality to identify water and bank features and that covered the entire study area.

The following measurements were made from aerial photographs for each reach:

1. Thalweg length (length of the path where most of the water flows).
2. Chord length (straight-line length from beginning to ending of reach).
3. Cumulative length of side channels.
4. Cumulative length of alcoves.
5. Length of main channel bank bordered by a gravel bar.
6. Sinuosity of each reach (calculated by dividing thalweg length by chord length).

The above measurements were selected to describe river geomorphology because they directly relate to fish habitat quality. A reach with high sinuosity usually has a diverse array of fish habitat features including varied water depth, water velocity, and sediment size. A reach with greater side channel length usually has a greater degree of habitat diversity for fish. Side channels can provide early season feeding areas, refuge from fast-flowing water, and protection from main channel predator fish. A reach with greater alcove length usually can provide a range of specialized fish habitat features. Alcoves are often used by native fish for breeding and rearing. The still and shallow water during the summer often promotes growth of aquatic plants and associated food webs. Finally, a reach with abundant gravel bordering the banks usually has a greater abundance of aquatic insects and other food items for fish.

*Channel length and sinuosity*

Between 1944 and 2000, the length of the rivers in the study area decreased 3.5 miles or 8%. Overall, sinuosity also decreased 8%. The decrease in reach 2 was largely an artifact of the mouth of the McKenzie River moving upstream several miles. Sinuosity declines were most significant in the McKenzie River and the Coast Fork Willamette River (Figure 7) and are related to deliberate attempts to keep the rivers from meandering. Some decline in sinuosity occurred prior to the 1944 aerial photographs, but the extent is unknown.

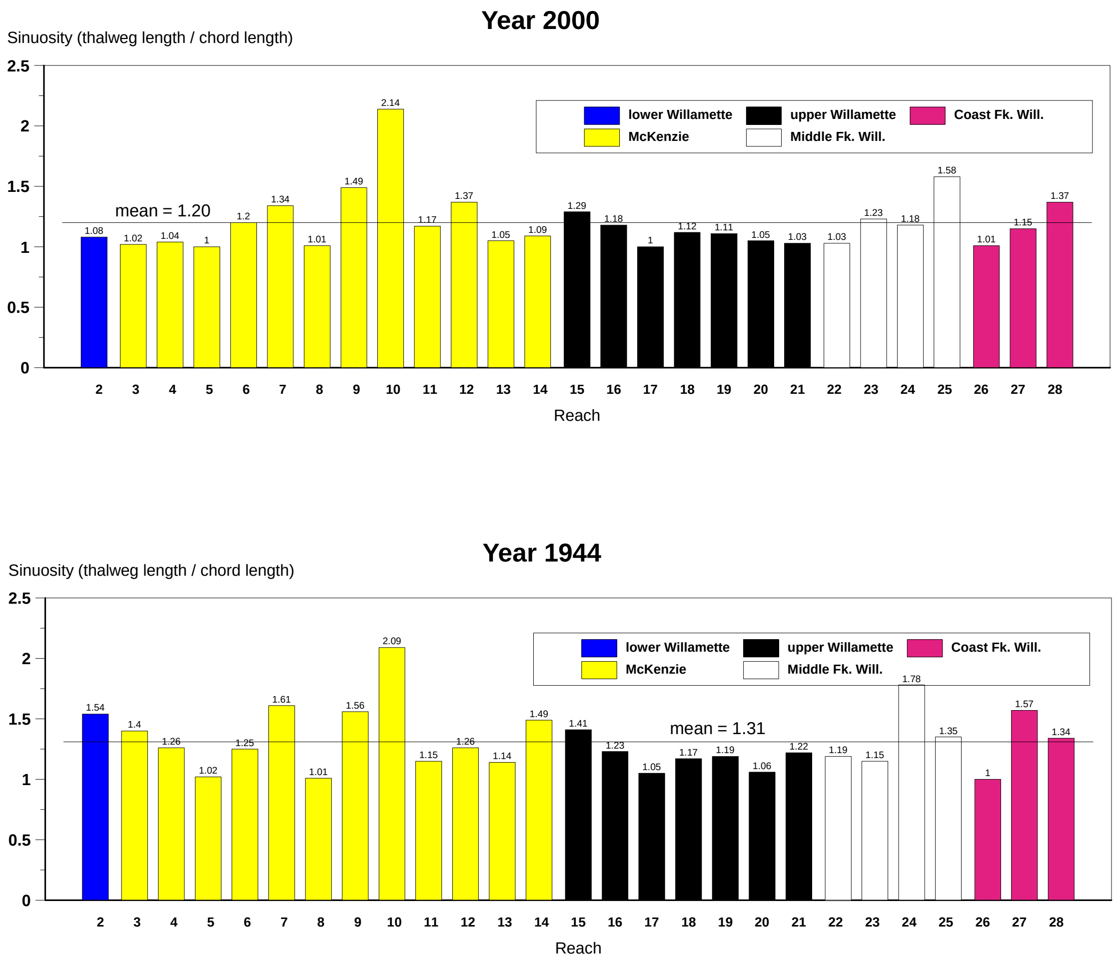



**Figure 7. Channel sinuosity by reach for current conditions (2000) and pre-reservoir conditions (1944).** See Map 10a for a display of river reach boundaries.

Reaches that currently have the highest sinuosity occur mostly in the McKenzie River near Springfield (Table 5) or the Middle Fork of the Willamette River. Also, a reach immediately upstream of the McKenzie River confluence has high sinuosity. Because of their current high sinuosity, these reaches would be most appropriate for protection.

**<u>Table 5</u>. Seven highest ranking river reaches for channel sinuosity in year 2000.**

| Ranking | Reach | River | Year 2000 sinuosity (feet/feet) |
|---|---|---|---|
| 1 | 10 | McKenzie | 2.14 |
| 2 | 25 | Middle Fork Will. | 1.58 |
| 3 | 9 | McKenzie | 1.49 |
| 4 | 28 | Middle Fork Will. | 1.37 |
| 5 | 12 | McKenzie | 1.37 |
| 6 | 7 | McKenzie | 1.34 |
| 7 | 15 | Upper Willamette | 1.29 |

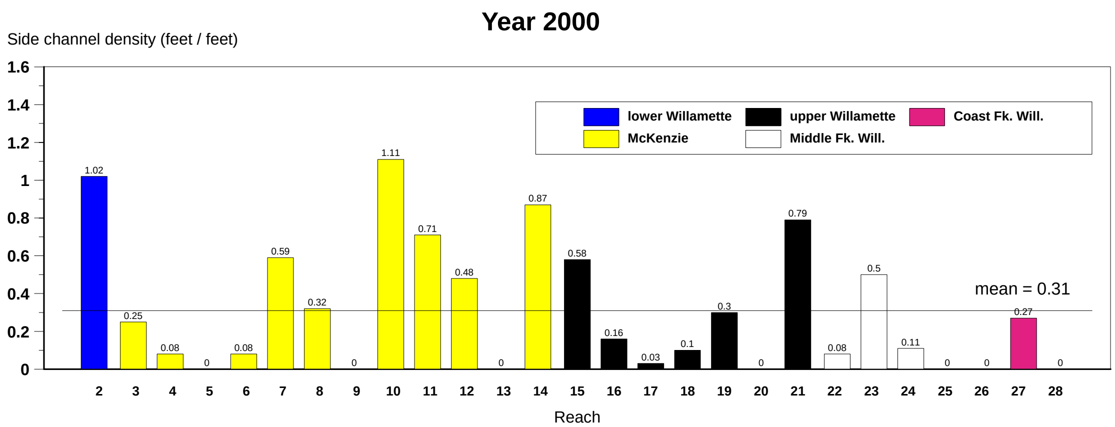
Reaches that had the greatest amount of sinuosity loss (Table 6) would be most appropriate for <u>restoration</u>, assuming that other factors, such as adjacent deep gravel pit ponds, allowed such restoration. These high priority restoration reaches occur in the lower McKenzie River and scattered reaches in the Middle Fork Willamette River, Lower Willamette River, and Coast Fork Willamette River. Restoring the sinuosity to reaches 3 and 4 may be hindered by the diked and riprapped banks and the adjacent gravel pits in this area.

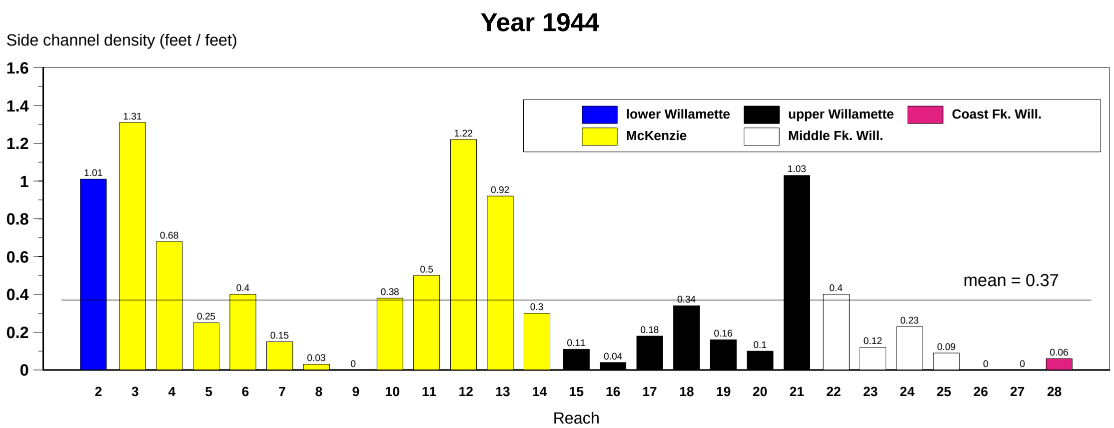
**<u>Table 6</u>. Seven highest ranking river reaches for loss in channel sinuosity between year 1944 and year 2000.**

| Ranking | Reach | River | Year 1944 sinuosity (feet/feet) | Year 2000 sinuosity (feet/feet) | Sinuosity loss (feet/feet) |
|---|---|---|---|---|---|
| 1 | 24 | Middle Fork Will. | 1.78 | 1.18 | 0.60 |
| 2 | 2 | Lower Willamette | 1.54 | 1.08 | 0.46 |
| 3 | 27 | Coast Fork Will. | 1.57 | 1.15 | 0.42 |
| 4 | 14 | McKenzie | 1.49 | 1.09 | 0.40 |
| 5 | 3 | McKenzie | 1.40 | 1.02 | 0.39 |
| 6 | 7 | McKenzie | 1.61 | 1.34 | 0.26 |
| 7 | 4 | McKenzie | 1.26 | 1.04 | 0.22 |

*Side channel abundance*

Between 1944 and 2000, the length of side channels associated with rivers in the study area declined 2.4 miles, or a 15% loss. Side channel losses were most significant in the McKenzie River (23% decline), with much of the loss occurring downstream of the Interstate Highway 5 bridge where extensive gravel mining occurs. Currently, 7 of the 27 reaches lack side channels, while only 3 reaches lacked side channels in 1944 (Figure 8).




**<u>Figure 8</u>. Side channel density by reach for current conditions (2000) and pre-reservoir conditions (1944).** See Map 10a for a display of river reach boundaries.

Reaches that currently have the highest density of side channels include McKenzie River reaches near Springfield and two Willamette River reaches immediately above and below the McKenzie River confluence (Table 7). Reach 21 on the Middle Fork Willamette River is also high. Because of their current high density of side channels, these reaches would be high priority candidates for protection.

Nearly all reaches with the greatest loss of side channels occur in the McKenzie River, especially in the most downstream section that has extensive gravel mining (Table 8). Reach 22 in the Middle Fork Willamette River has also undergone a large loss of side channels. Those reaches with the largest loss in side channel length between 1944 and 2000 would be top candidates for restoration, depending on physical and economic barriers to restoration.

**Table 7. Seven highest ranking river reaches for per unit side channel length in year 2000.**

| Ranking | Reach | River | Year 2000 length (feet/feet) |
|---|---|---|---|
| 1 | 10 | McKenzie | 1.11 |
| 2 | 2 | Lower Willamette | 1.02 |
| 3 | 14 | McKenzie | 0.87 |
| 4 | 21 | Middle Fork Will. | 0.79 |
| 5 | 11 | McKenzie | 0.71 |
| 6 | 7 | McKenzie | 0.59 |
| 7 | 15 | Upper Willamette | 0.58 |

**Table 8. Seven highest ranking river reaches for loss in per unit side channel length between year 1944 and year 2000.**

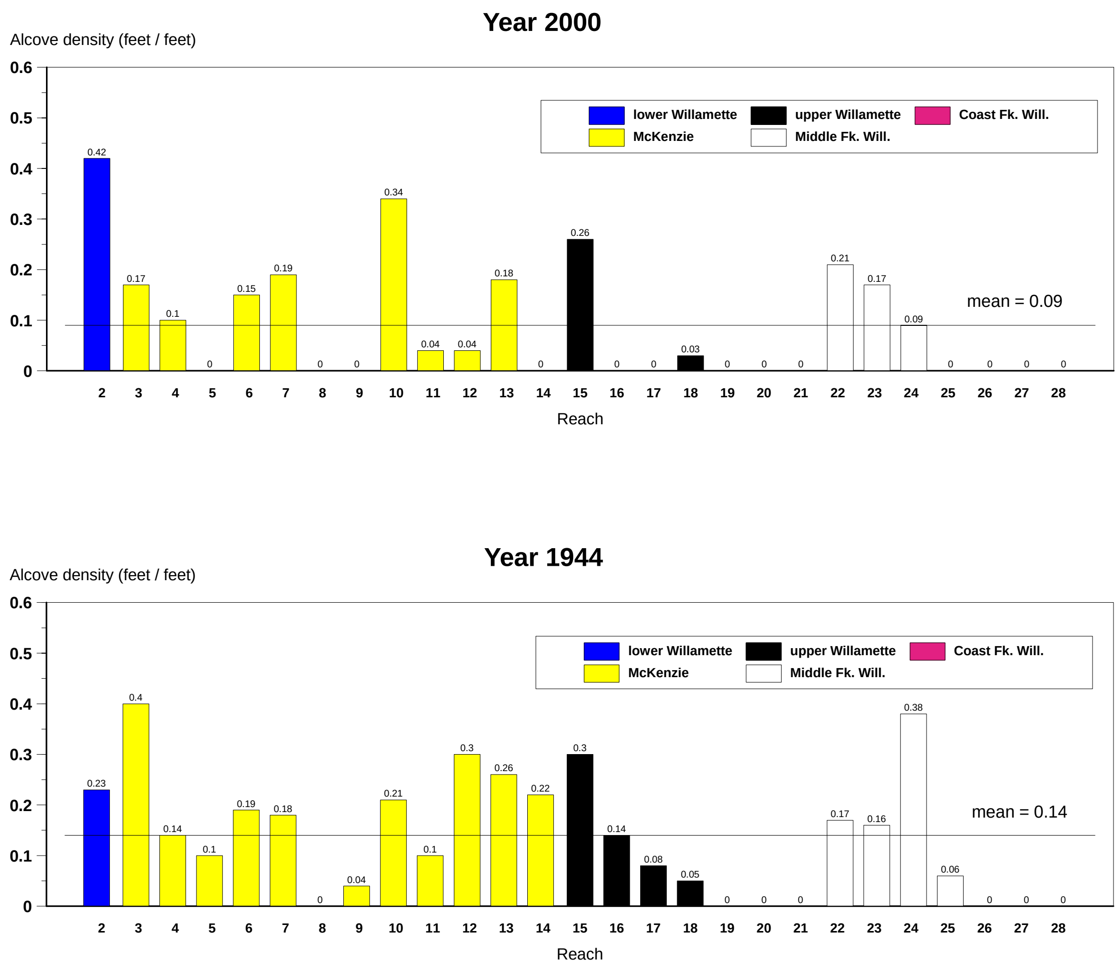
| Ranking | Reach | River | Year 1944 length (feet/feet) | Year 2000 length (feet/feet) | Side channel loss (feet/feet) |
|---|---|---|---|---|---|
| 1 | 3 | McKenzie | 1.31 | 0.25 | 1.06 |
| 2 | 13 | McKenzie | 0.93 | 0.00 | 0.92 |
| 3 | 12 | McKenzie | 1.22 | 0.48 | 0.74 |
| 4 | 4 | McKenzie | 0.68 | 0.08 | 0.60 |
| 5 | 22 | Middle Fork Will. | 0.40 | 0.08 | 0.32 |
| 6 | 6 | McKenzie | 0.40 | 0.08 | 0.32 |
| 7 | 5 | McKenzie | 0.25 | 0.00 | 0.25 |

*Alcove abundance*

Between 1944 and 2000, the length of alcoves associated with rivers in the study area declined 2.6 miles, or a 39% loss. Alcove losses were most significant in the McKenzie River (42% decline) and in the upper Willamette River (45% decline). Currently, nearly half of the 27 reaches lack alcoves, while only one-quarter of the reaches lacked alcoves in 1944 (Figure 9).

Reaches that currently have the highest density of alcoves include the lower McKenzie River and two Willamette River reaches immediately above and below the McKenzie River confluence (Table 9). Reach 22 on the Middle Fork Willamette River is also high. Because of their current high density of alcoves, these reaches would be priority candidates for protection.

A majority of reaches with the greatest loss in per unit alcove length occur in the McKenzie River (Table 10a). Reach 22 on the Middle Fork Willamette River has also undergone a large loss of alcoves. Those reaches with the largest loss in alcove length between 1944 and 2000 would be top candidates for restoration, depending on physical and economic barriers to restoration.




**<u>Figure 9</u>. Alcove density by reach for current conditions (2000) and pre-reservoir conditions (1944).** See Map 10a for a display of river reach boundaries.

**<u>Table 9</u>. Seven highest ranking river reaches for per unit alcove length in year 2000.**

| Ranking | Reach | River | Year 2000 length (feet/feet) |
|---|---|---|---|
| 1 | 2 | Lower Willamette | 0.42 |
| 2 | 10 | McKenzie | 0.34 |
| 3 | 15 | Upper Willamette | 0.26 |
| 4 | 22 | Middle Fork Will. | 0.21 |
| 5 | 7 | McKenzie | 0.19 |
| 6 | 13 | McKenzie | 0.18 |
| 7 | 3 | McKenzie | 0.17 |

**<u>Table 10</u>. Seven highest ranking river reaches for loss in per unit alcove length between year 1944 and year 2000.**

| Ranking | Reach | River | Year 1944 length (feet/feet) | Year 2000 length (feet/feet) | Alcove loss (feet/feet) |
|---|---|---|---|---|---|
| 1 | 24 | Middle Fork Will. | 0.38 | 0.09 | 0.28 |
| 2 | 12 | McKenzie | 0.30 | 0.04 | 0.26 |
| 3 | 3 | McKenzie | 0.40 | 0.17 | 0.23 |
| 4 | 14 | McKenzie | 0.22 | 0.00 | 0.22 |
| 5 | 16 | Upper Willamette | 0.14 | 0.00 | 0.14 |
| 6 | 5 | McKenzie | 0.10 | 0.00 | 0.10 |
| 7 | 17 | Upper Willamette | 0.08 | 0.00 | 0.08 |

### *Gravel bar abundance along the main channel*

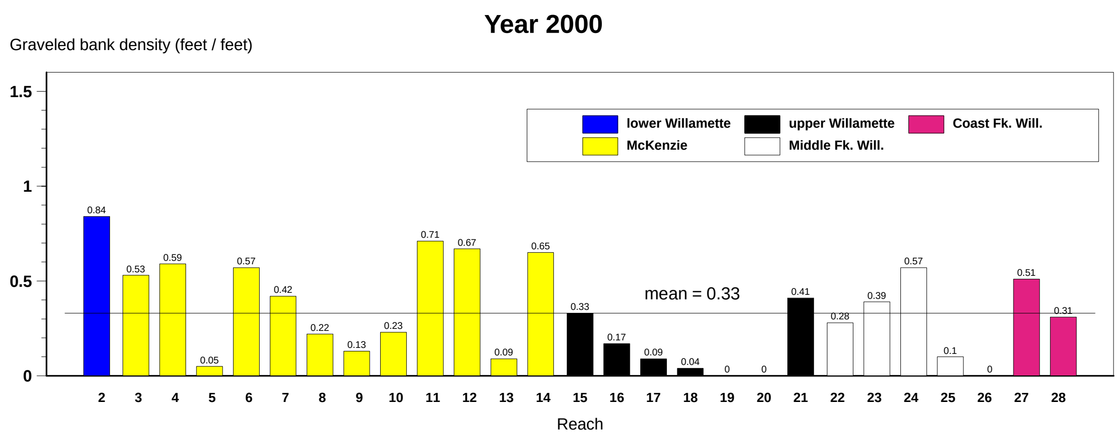
Between 1944 and 2000, the length of river bank bordered by bare gravel in the study area declined by 16.4 miles, or a 54% loss (Figure 10). Gravel bar losses were most significant in the Upper Willamette River (84% decline), in the Coast Fork Willamette River (69% decline), and in the Middle Fork Willamette River (65% decline). The decline in unvegetated gravel bars can be attributed to gravel removal, the reduction in peak flows following dam construction, and an influx of introduced plant species such as reed canarygrass and blackberry that readily invade low-lying gravel areas of the river.

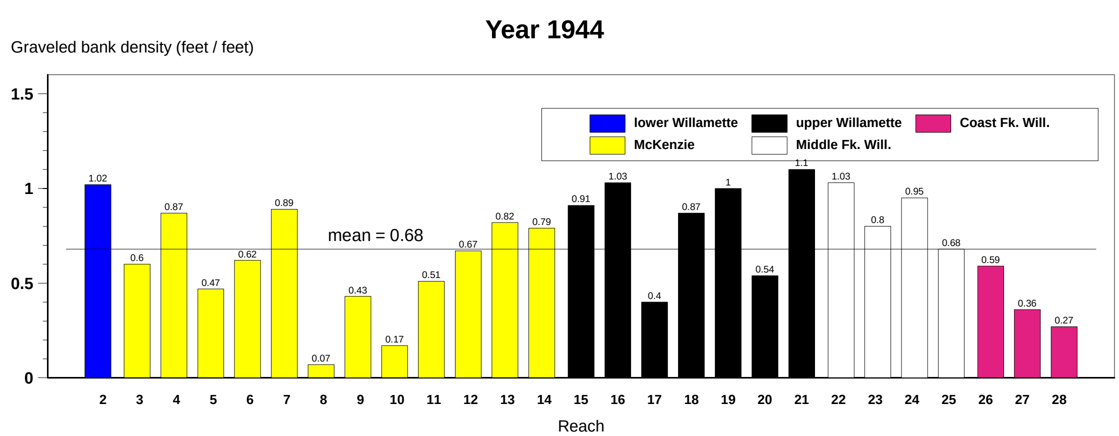
Areas that currently have the highest abundance of bare gravel bars include reaches in the McKenzie River and the Willamette River reach immediately above the McKenzie River confluence (Table 11). Reach 24 on the Middle Fork Willamette River is also high. Because of their current high density of bare gravel bars, these reaches would be candidates for protection.

**<u>Table 11</u>. Seven highest ranking river reaches for per unit gravel bar length in year 2000.**

| Ranking | Reach | River | Year 2000 length (feet/feet) |
|---|---|---|---|
| 1 | 2 | Lower Willamette | 0.84 |
| 2 | 11 | McKenzie | 0.71 |
| 3 | 12 | McKenzie | 0.67 |
| 4 | 14 | McKenzie | 0.65 |
| 5 | 4 | McKenzie | 0.59 |
| 6 | 24 | Middle Fork Will. | 0.57 |
| 7 | 6 | McKenzie | 0.57 |

A majority of reaches with the greatest loss of bare gravel bars occur in the upper Willamette River near downtown Eugene and a few scattered sites in each of the other three rivers (Table 12). Those reaches with the largest loss in gravel bar length between 1944 and 2000 would be top candidates for restoration, depending on physical and economic barriers to restoration. Sites near downtown Eugene would be difficult to restore because extensive gravel mining removed much of the aggregate during the 1940s and 1950s and the west side of the main channel is crowded by riprapped bank and buildings. It is probably not realistic to expect that gravel bars can be restored to this area since the peak flows needed to initiate river meandering in the Middle Fork Willamette River and the uptake of gravels from retreating banks would inundate a significant amount of human infrastructure between Dexter Dam and the McKenzie River confluence. Reservoir management currently dampens peak flows by about 78%. The alternative to increasing peak flows to get gravel deposition in the Eugene stretch of the Willamette River is to extract it from near-river sites and place it in the channel. This would involve a tremendous cost and the benefits resulting from this cost would be relatively small considering that Chinook salmon are not capable of spawning here (the reservoirs create water that is too warm in the fall).




**<u>Figure 10</u>. Gravel bar density by reach for current conditions (2000) and pre-reservoir conditions (1944).** See Map 10a for a display of river reach boundaries.

**<u>Table 12</u>. Seven highest ranking river reaches for loss in per unit gravel bar length between year 1944 and year 2000.**

| Ranking | Reach | River | Year 1944 length (feet/feet) | Year 2000 length (feet/feet) | Gravel bar loss (feet/feet) |
|---|---|---|---|---|---|
| 1 | 19 | Upper Willamette | 1.00 | 0.00 | 1.00 |
| 2 | 16 | Upper Willamette | 1.03 | 0.17 | 0.86 |
| 3 | 18 | Upper Willamette | 0.87 | 0.04 | 0.83 |
| 4 | 22 | Middle Fork Will. | 1.03 | 0.28 | 0.75 |
| 5 | 13 | McKenzie | 0.82 | 0.09 | 0.73 |
| 6 | 21 | Middle Fork Will. | 1.10 | 0.41 | 0.69 |
| 7 | 26 | Coast Fork Will. | 0.59 | 0.00 | 0.59 |

A summary of physical characteristics of each study area river for the two time periods are displayed in Table 13.

**Table 13**. **Summary of physical characteristics of river segments in 1944 and 2000.**

| | Year 1944 | Year 2000 | Percent change |
|---|---|---|---|
| ***Overall (reaches 2-28)*** | | | |
| Main channel; length of thalweg (miles) | 45.62 | 42.09 | -8 |
| Main channel; length of chord distance (miles) | 34.81 | 34.81 | 0 |
| Sinuosity | 1.31 | 1.21 | -8 |
| Side channel; length (miles) | 15.65 | 13.22 | -15 |
| Alcove; length (miles) | 6.58 | 4.01 | -39 |
| Gravel bar; length of main channel bank (miles) | 30.19 | 13.77 | -54 |
| ***Lower Willamette River (reach 2)*** | | | |
| Main channel; length of thalweg (miles) | 1.33 | 0.81 | -39 |
| Main channel; length of chord distance (miles) | 0.86 | 0.75 | -13 |
| Sinuosity | 1.54 | 1.08 | -30 |
| Side channel; length (miles) | 1.34 | 0.83 | -39 |
| Alcove; length (miles) | 0.30 | 0.34 | +13 |
| Gravel bar; length of main channel bank (miles) | 1.36 | 0.68 | -50 |
| ***McKenzie River (reaches 3-14)*** | | | |
| Main channel; length of thalweg (miles) | 19.68 | 18.04 | -8 |
| Main channel; length of chord distance (miles) | 14.52 | 14.40 | -1 |
| Sinuosity | 1.36 | 1.25 | -8 |
| Side channel; length (miles) | 10.29 | 7.89 | -23 |
| Alcove; length (miles) | 3.73 | 2.15 | -42 |
| Gravel bar; length of main channel bank (miles) | 11.03 | 7.58 | -31 |
| ***Upper Willamette River (reaches 15-21)*** | | | |
| Main channel; length of thalweg (miles) | 12.13 | 11.67 | -4 |
| Main channel; length of chord distance (miles) | 10.19 | 10.30 | +1 |
| Sinuosity | 1.19 | 1.13 | -5 |
| Side channel; length (miles) | 2.50 | 2.70 | +8 |
| Alcove; length (miles) | 3.73 | 0.73 | -45 |
| Gravel bar; length of main channel bank (miles) | 10.00 | 1.63 | -84 |
| ***Middle Fork Willamette River (reaches 22-25)*** | | | |
| Main channel; length of thalweg (miles) | 7.12 | 6.98 | -2 |
| Main channel; length of chord distance (miles) | 5.47 | 5.58 | +2 |
| Sinuosity | 1.30 | 1.25 | -4 |
| Side channel; length (miles) | 1.39 | 1.24 | -11 |
| Alcove; length (miles) | 1.22 | 0.79 | -35 |
| Gravel bar; length of main channel bank (miles) | 5.99 | 2.17 | -65 |
| ***Coast Fork Willamette River (reaches 26-28)*** | | | |
| Main channel; length of thalweg (miles) | 5.36 | 4.59 | -14 |
| Main channel; length of chord distance (miles) | 3.77 | 3.77 | 0 |
| Sinuosity | 1.42 | 1.22 | -14 |
| Side channel; length (miles) | 0.13 | 0.57 | +345 |
| Alcove; length (miles) | 0.00 | 0.00 | 0 |
| Gravel bar; length of main channel bank (miles) | 1.81 | 0.57 | -69 |

### 2.1.6 Fish habitat index based on geomorphology

The four above-mentioned channel characteristics were combined into a single index of fish habitat quality so that the reaches could be ranked according to overall fish habitat quality based on geomorphology. The data was then transformed in the following way. For the series of values associated with each parameter (sinuosity, side channel density, alcove density, and bare gravel bar density), the values were standardized. This was accomplished by applying the following equation:

Standardized value = (X – Xmin) / (Xmax –Xmin)

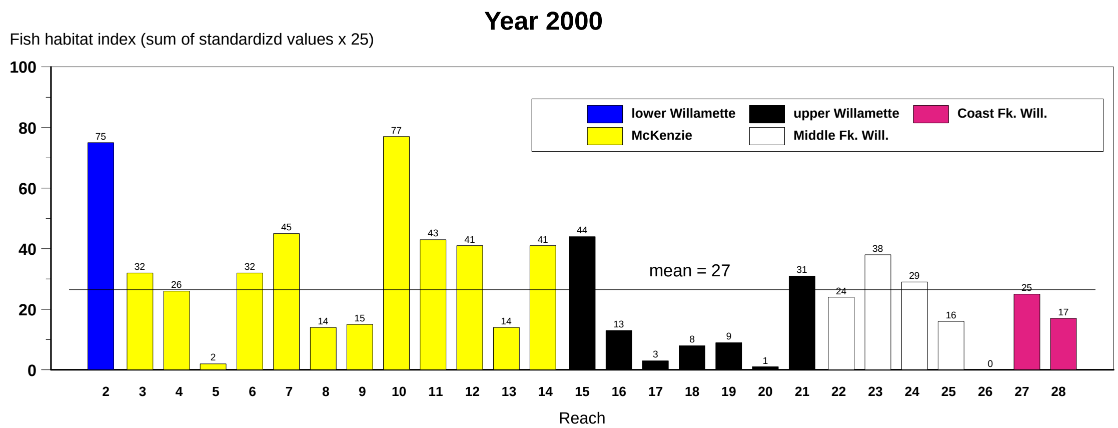
where: X is the value for the reach,
Xmin is the minimum value among the 27 reaches, and
Xmax is the maximum value among the 27 reaches.

This transformation resulted in a list of values that ranged from 0 to 1 for each parameter, with 1 being the highest value and 0 being the lowest value.

The standardized values for the four parameters was added and then multiplied by 25 in order to end up with an index that ranged from 0 to 100. This was called the fish habitat index. It was assumed that each of the four parameters had equal weight in defining fish habitat quality. Reaches with a high fish habitat index (a theoretical maximum of 100) were considered the best habitat and reaches with a low fish habitat index (a theoretical minimum of 0) were considered the worst habitat. This was done separately for both 2000 and 1944 conditions (Figure 11).

The fish habitat index is currently greatest in reaches of the McKenzie River within and upstream of Springfield and two Willamette River reaches immediately upstream and downstream of the McKenzie River confluence (Table 14). Reach 13, the only upper McKenzie River reach that does not currently have a high fish habitat ranking, had the greatest loss in fish habitat index between 1944 and 2000 (Figure 11). Other reaches with unusually high losses in fish habitat index include reach 12 and reach 3 in the McKenzie River (Table 15). Reaches 13 and 12 would be high priority for restoration because of the scarcity of human development next to the river. However, improvements for reach 3 would be more difficult because of the adjacent gravel mining and riprapped banks.

Reaches 22 and 24 in the Middle Fork Willamette also had large losses in fish habitat quality and would be candidates for restoration. Reach 24 holds special promise because of the lack of development and river-adjacent gravel ponds. Losses in fish habitat were high in two upper Willamette River reaches (16 and 18), but restoring complexity to these reaches would be frustrated by extensive development and riprap along the west bank and the removal of in-channel gravel during the 1940s and 1950s.



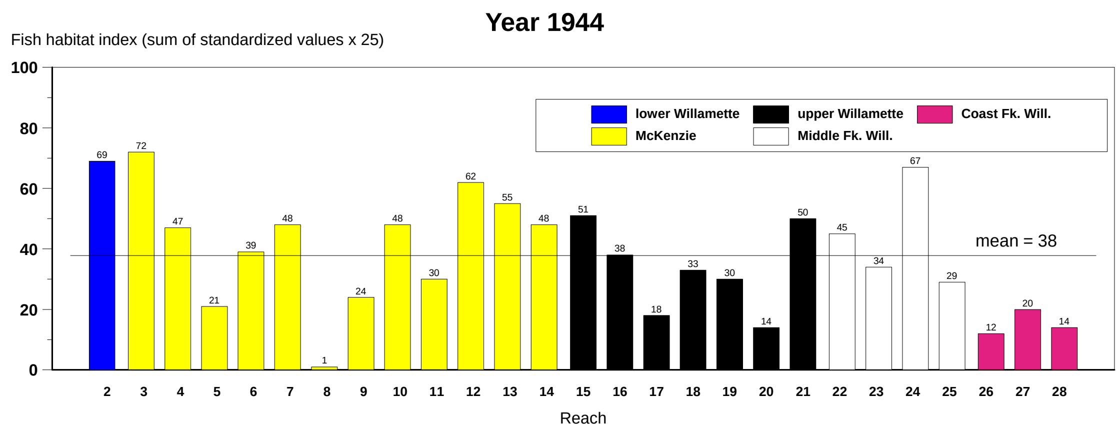




**Figure 11. Fish habitat index by reach for current conditions (2000) and pre-reservoir conditions (1944).** See Map 10a for a display of river reach boundaries. Fish habitat index was determined by summing the standardized values for sinuosity, side channel length, alcove length, and length of main channel bank bordered by gravel bars and then multiplying by 25.

**Table 14. Seven highest ranking river reaches for fish habitat index in year 2000.**

| Ranking | Reach | River | Year 2000 index |
|---|---|---|---|
| 1 | 10 | McKenzie | 77 |
| 2 | 2 | Lower Willamette | 75 |
| 3 | 7 | McKenzie | 45 |
| 4 | 15 | Upper Willamette | 44 |
| 5 | 11 | McKenzie | 43 |
| 6 | 12 | McKenzie | 41 |
| 7 | 14 | McKenzie | 41 |

**Table 15. Seven highest ranking river reaches for loss in fish habitat index between year 1944 and year 2000.**

| Ranking | Reach | River | Year 1944 index | Year 2000 Index | Fish habitat index loss |
|---|---|---|---|---|---|
| 1 | 13 | McKenzie | 55 | 14 | 41 |
| 2 | 3 | McKenzie | 72 | 32 | 40 |
| 3 | 24 | Middle Fork Will. | 67 | 29 | 38 |
| 4 | 16 | Upper Willamette | 38 | 13 | 25 |
| 5 | 18 | Upper Willamette | 33 | 8 | 25 |
| 6 | 22 | Middle Fork Will. | 45 | 24 | 21 |
| 7 | 12 | McKenzie | 62 | 41 | 21 |

### 2.1.7 Riparian vegetation alongside rivers

Along with changes in channel geomorphology, riparian vegetation next to the rivers has also changed over the last six decades. An example of this change for the McKenzie River from reach 2-14 is provided using aerial photographs from 1944 and 2000 (Alsea Geospatial et al. 2001). These reaches encompass the extent of the McKenzie River that falls within the MECT study area. Vegetation types were evaluated 500 feet each side of the river and the areas by vegetation type were tabulated for each reach.

Results from this evaluation indicate that the percent total area within 500 feet of the river comprised of fields and orchards has not changed, but the percent occupied by hardwood and shrubs has increased considerably (Figure 12). In 1944, only about one-quarter of the area supported willows, shrubs, and hardwoods less than 40 years old. This area increased to over one-half of the area by 2000. Correspondingly, there were sharp declines in the area of hardwoods greater than 40 years old, bare substrate, and grass. The muting of peak flows by reservoirs has allowed vegetation to encroach upon the river edges, while harvest of older trees for timber and development has depleted older age classes of trees. Rural residential and urban development was only 0.3% of the area in 1944 because of the flood hazard, but increased to 7.3% by 2000.

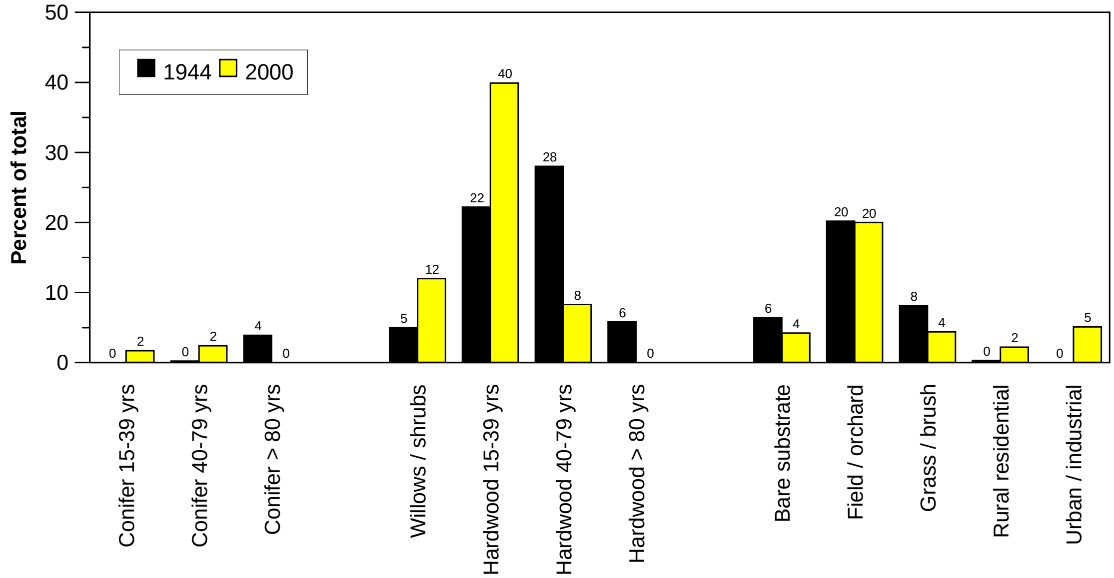



**Figure 12. Changes in vegetation and land use for the McKenzie River (reaches 2-14) between 1944 and 2000 (Alsea Geospatial et al. 2001).** Calculated using the area of land 500 feet each side of the river. The 500 feet wrapped around side channels and alcoves. Included in the calculation was the vegetation on islands of land between the main channel and side channels or alcoves.

The changes in riparian vegetation and land use over the last six decades have likely contributed to a decline in fish habitat. Young vegetation encroaching upon the river has stabilized gravel bars and has probably resulted in less gravel bar movement, which can negatively affect the abundance of aquatic insects and periphyton used by fish for food. Also, a river with heavily-vegetated lower banks is less likely to meander, thereby slowing down the processes that create and modify off-channel features along the river. The scarcity of large trees along the river contributes to the deficit of large wood in the river. This wood creates channel roughness features that fish can use to find cover and maintain desirable feeding spots.

Much of the interaction between land and water occurs within the narrow corridor that is within 100 feet of the river edge. For example, trees growing close to the stream are those most likely to contribute large wood, litter, bank hardening via their roots, and shade. It was determined that the current composition of riparian vegetation (within 100 feet of the main channel) for all rivers throughout the study area using 2000 aerial photographs and expressed categories as a percent of the total bank length (Table 16).

**Table 16. Summary of percent current vegetation, gravel bars, and development within 100 feet of the edge of rivers within the study area by groups of reaches.** Developed areas includes roads, paved or graveled lots, dikes, gravel extraction areas, or buildings.

| | Overall (#2-28) | Lower Willamette (#2) | Lower McKenzie (#3-14) | Upper Willamette (#15-21) | Middle Fk. Willamette (#22-25) | Coast Fk. Willamette (#26-28) |
|---|---|---|---|---|---|---|
| Hardwood trees | 57.2% | 32.4% | 50.3% | 64.1% | 48.2% | 77.7% |
| Mixed conifer and hardwood trees | 1.9 | 0.0 | 0.2 | 0.0 | 11.4 | 0.0 |
| Shrubs (including willows) | 15.9 | 39.7 | 20.5 | 10.8 | 15.4 | 13.4 |
| Grass, pasture, fields | 8.0 | 0.0 | 7.7 | 10.7 | 7.6 | 5.0 |
| Orchards (filberts) | 0.9 | 0.0 | 0.0 | 0.0 | 4.5 | 0.0 |
| Gravel bars | 11.2 | 27.9 | 16.3 | 4.8 | 12.9 | 4.0 |
| Developed areas | 4.9 | 0.0 | 5.0 | 9.5 | 0.0 | 0.0 |
| Total | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

Overall, vegetation of various types dominates the 100-foot-wide corridor next to study area rivers. Less than 5% of bank length is developed in this zone. Hardwood trees occupied more than 50% of river banks. Conifer trees are nearly absent. Development along the upper Willamette River reaches is the highest among the rivers, but still makes up less than 10% of river banks. While development along the west bank of this section of river is widespread, it is usually set back from the edge of the river more than 100 feet. Development within the 100-foot corridor does not exist for lower Willamette, Middle Fork Willamette, and Coast Fork Willamette reaches.

The percentage of banks occupied by shrubs is greatest along lower Willamette River and lower McKenzie River reaches. Here, the river was once lined by extensive areas of gravel bars. Since peak flows have been dampened at reservoirs, shrubs have established themselves close to the water edge. Shrubs growing along study area rivers are a combination of native species, such as willows, and exotic species, such as blackberry and Scotch broom. Hardwood trees are mostly young with only a few patches greater than 80 years old. Nevertheless, other than those trees located between riverfront houses and the water, few cases where observed where trees had recently been removed. The growth of ash and cottonwood trees can be rapid when located near water and many of these hardwood stands will begin developing mature characteristics in a few decades.

### 2.1.8 Conclusions, recommended actions, and information gaps about river geomorphology and vegetation

The fish habitat index developed for this project provides an objective way for determining physical habitat quality that can be extracted from historic aerial photographs, thereby allowing a comparison of pre-reservoir conditions with the present. For all reaches combined, each of the four parameters that make up the index have declined since 1944. Main channel sinuosity declined the least (8%) while gravel bar abundance declined the most (54%). Declines in fish habitat quality probably also occurred prior to 1944, but there were no available data with which we could quantify these changes. Among those pre-1944 changes were the clearing and straightening of channels to allow log drives and boat traffic.

With exceptions, reaches that had good physical fish habitat in 1944 still retain those characteristics today. Reaches 7 and 10 through 14 of the lower McKenzie had some of the best habitat in 1944 and all except reach 13 still have above-average habitat. This portion of the McKenzie River is a depositional area with a low gradient and a wide river meander belt and would be qualified as high priority for protection (reaches 7, 10-12, and 14) and restoration (reach 13). Indeed, the reach rated as highest for physical fish habitat among all study area reaches (reach 10) currently has a high level of protection due to the establishment of the Weyerhaeuser-McKenzie Nature Reserve on much of the south bank and conservation easements (established by the McKenzie Land Trust) on much of the north bank. The siting of riverfront homes along the edges of the McKenzie River, common upstream of the study area, is beginning to extend downstream into reaches 8-14 of the study, thereby making it more difficult to retain river characteristics that create high-quality fish habitat.

The McKenzie River downstream of Interstate 5 once had exceptional fish habitat due to its delta-like characteristics. This area has been and will continue to be mined for gravel along the boundaries of the main channel. Opportunities to restore the original geometry of the river are limited by deep gravel pits behind the confining riverside dikes. Simple solutions such as running the river through the mined-out pits are not feasible because much of the river's gravel load would be trapped in the pits. Trapping of the gravel would rob downstream reaches of gravel replenishment. Nevertheless, there may be ways to shuttle a portion of the river (minus its gravel load) into abandoned gravel pits in a controlled fashion thereby providing unique habitat features beneficial to native fish.

Willamette River reaches 2 and 15, located immediately downstream and upstream of the McKenzie River confluence have high quality fish habitat that would be high priority for protection. Reach 15 is bordered by gravel pits and faces some of the same constraints as the lower McKenzie River reaches. However, the flood plain is wide in reach 15 and there are more opportunities for the river to meander. Reach 24 in the Middle Fork Willamette River once had some of the highest quality fish habitat in the study area and habitat quality is still above average. This reach would be high priority for restoration since its historic flood plain has yet to be developed. Re-introducing channel complexity would be most challenging in Middle Fork Willamette River reaches since it is the study area river that has suffered the greatest reduction in peak flows (a 4.5-fold decrease in the 100-year peak discharge). Nevertheless, channel features, such as alcoves, have been mechanically excavated in other reaches of the Willamette with good results. However, the cost of excavation is high and the permitting process difficult.

Upstream reservoirs are still the most powerful influence on fish habitat in rivers of the study area. Reservoirs will continue to be managed so that peak flows are dampened due to development in the historic flood plain and this will prevent the high flows needed to create channel meandering that results in sinuosity, side channels, alcoves, and bare gravel bars. The dikes and riprapped banks also contribute to a lack of river meandering. Nevertheless, in most areas, dikes and riprapped banks are not widespread. Continuing to allow site development at the edge of the river and its low flood plains will put further pressure on the Corps of Engineers to dampen peak flows at upstream reservoirs in order to minimize economic losses during high water and to approve future riprap projects to protect development from river meandering.

The edges of the rivers in the study area are more heavily vegetated than prior to reservoirs, a time when unfettered peak flows kept vegetation from establishing in a wide swath. Also, trees are much younger due to timber harvest and land clearing and exotic species of vegetation are crowding out native plants. While the heavily vegetated banks help keep the river from meandering, this also leads to declining fish habitat quality as gravels are immobilized and river complexity is reduced.

The best opportunity to improve vegetative conditions along study area rivers is to convert areas choked with exotic brush species to native trees and shrubs. Because native grass, shrub, and tree species are naturally adapted to habitats within the study area, they require less effort (E.g., less water and fertilizer) to establish and maintain and they provide habitat benefits to wildlife species that are adapted to using them for food and shelter. Unfortunately, the exotic species most prevalent are those most difficult to eliminate. Blackberry, Scotch broom, and reed canarygrass rapidly re-colonize areas that are simply cleared by grubbing. Scotch broom and reed canarygrass can be controlled by glyphosate-based herbicides, but will likely require repeated applications over a period of a decade. Blackberry requires more toxic compounds to control. Alternative techniques for blackberry and weed control, such as repeated mowing or goat grazing, have been successful but it is difficult to concurrently establish native vegetation. Planting areas with bare river deposits is not recommended since high flows will usually wash away the plants.

The option to re-establish widespread areas of bare sediments along river edges, as existed prior to dam construction, is probably not realistic. The tenacity of exotic plants and the public's reluctance to use herbicides near water, probably precludes restoration of this important river feature.

Concerns over lawsuits have caused some towns along the Willamette River (Albany, Corvallis, Independence) to remove large native riparian trees in portions of their riverside parks. Some hold the belief that native trees, such as cottonwood, are too dangerous during wind storms and, instead of siting structures and playground equipment in open areas, have removed the trees instead. Intentional policy decisions made on tree removal in parks today can prevent haphazard and widespread tree removal in parks over the long term.

**Recommendations:**

1. Efforts to protect segments of the river from development would benefit fish most if focused on reaches that currently have high quality physical habitat. High quality reaches include reaches 7, 10-12, and 14 on the McKenzie River and the two reaches of the Willamette River immediately upstream and downstream of the McKenzie River confluence.

2. Efforts to restore segments of the river would benefit fish most if focused on reaches that have the largest difference between historic and current physical habitat quality and have no serious barriers to restoration, such as adjacent deep gravel pit mines or buildings. Such reaches include #12 and 13 on the McKenzie River and #22 and 24 of the Middle Fork Willamette River.

3. Large wood is scarce in study area rivers. The supply of large wood is limited by reservoirs and it is being removed from rivers as quickly as it enters. Increasing large wood abundance could be accomplished by encouraging the Corps of Engineers to truck wood trapped at reservoirs and put in the river downstream of the dam and by passing local ordinances that prohibit the removal of wood from rivers.

4. Riprap along river banks degrades fish habitat. About 17% of study area river banks are already riprapped. Local ordinances, along with firm enforcement, can be used to limit further expansion of riprap.

5. Peak flows are the sculptors of river channels and much fish habitat is lost when peak flows are muted by upstream reservoirs. While development along rivers prevents a return to historic peak flow regimes, some increase in peak flow magnitude and frequency is possible without flooding downstream landowners. In order to accomplish this, close coordination with the Corps of Engineers and Lane County would be needed.

6. Although tree planting is a common restoration activity, few opportunities exist for planting along study area rivers without first investing in extensive weed and brush control. These efforts need to extend beyond the time of planting in order to avoid tree mortality.

7. Riparian stands along rivers are young compared to historic conditions. Young trees provide rivers with fewer pieces of large wood than do older stands. Trees along rivers are commonly cut for improving views to the river, increasing open areas around houses, or for firewood. Local ordinances can be used to promote the growing of larger trees near rivers, especially conifer trees.

**Information gaps:**
None

## *2.2 Water types other than rivers*

Deciding on terminology for defining the many non-river waterways that lace the MECT study area was difficult. Some waterway segments were named as streams yet their excavated channels and small size gave them the same appearance as drainage ditches. Furthermore, a variety of names show up on maps to describe linear water features in the study area including, channel, ditch, stream, slough, waterway, mill race, and diversion channel. What the water feature looked like did not necessarily match what is commonly ascribed to these names. Matters were simplified in this assessment by grouping water types into the following classes:

- Waterway not artificially confined; includes streams with natural channels.
- Waterway artificially confined; includes streams that have been excavated, lined with concrete, or banks consisting of fill material (other than riprap), as well as, excavated channels that do not coincide with a historic stream course.
- Sloughs; includes wide channels with standing water that were once major channels of the river, but now contain little flow during the summer.
- Mill races; includes excavated channels or partially excavated-partially natural channels that are elevated above the current river flood plain, once were used to power machinery, and have water pumped or diverted into them from the river (Springfield Mill Race and Eugene Mill Race).
- Gravel pit ponds; includes active and abandoned ponds resulting from the mining of gravel along rivers.
- Other excavated ponds; includes other excavated ponds that are not a result of gravel mining.
- Natural ponds; includes ponds that are not a result of human excavation.

Sections of waterways that have been piped or buried were not addressed in this study. Three short waterway sections within Springfield were inadvertently omitted from this survey (River Glen Channel, Sportsway Channel, Astor Channel).

### 2.2.1 Magnitude of peak flow increases for streams

Impervious surfaces, such as roofs, pavement, and compacted soil, can cause urbanized streams to exhibit increased peak flows. Precipitation flowing over an impervious surface is shuttled downstream more rapidly than precipitation falling on and filtering through natural soils. This results in higher peaks and a shorter runoff period.

A modeling study of six small streams in Connecticut indicated that peak flows in urban basins were 1.5 to 6.1 times greater than peak flows in rural basins for the 2-year flow and 1.1 to 4.3 times greater for the 100-year flow. The lower end of this range applied to where 30% of the basin was served by storm sewers and the higher end of this range applied to where 90% of the area was served by storm sewers (Weiss 1990).

More locally, a modeling study of small urbanized drainages that flow into Cedar Creek in Springfield showed that peak flows were 2.5 to 3 times greater than if the area was not urbanized (CH2M Hill, Inc. 1984). Estimated peak flows (100-year) using an empirical method for undeveloped drainages was compared with a recently-completed FEMA modeling effort of an urbanized watershed in Salem, Oregon. The peak flow estimates for urbanized conditions were

3-fold greater than estimates assuming the watershed was not urbanized (Andrus, unpublished data).

Both of these Springfield and Salem drainages had most of their area served by storm sewers (an estimated 60 to 90 %), but increases in their 100-year peak flows were somewhat lower than for the modeled Connecticut urban basins. Unlike the skeletal and porous soils of Connecticut, Willamette Valley soils are generally high in clay and do not readily transport water subsurface once they are wet. Therefore, even under natural conditions, Willamette Valley bottom watersheds rapidly expand their surface drainage network during heavy rains through a series of ephemeral channels. Consequently, the difference in permeability between natural conditions and paved conditions is not as great as would be expected for areas with highly porous soils.

A regression analysis of 24 monitored basins in the Portland, Oregon, and Vancouver, Washington, metropolitan area indicated that total urbanization of an undeveloped basin can increase peak discharge as much as 3.5 times and almost double the volume of storm runoff. Variation in peak flow magnitude among the 24 basins was best explained by watershed area, area of undeveloped land (parks, forests, vacant lots, and agriculture) and length of street gutters (miles/sq.mi.). Peak flow magnitude increased with the length of street gutters, but was moderated by the amount of undeveloped land (Laenen 1980).

During a previous assessment, estimates of percent impervious surface were determined for small stormwater sub-basins throughout the MECT study area (Map 13). Percent impervious surface in the most densely developed areas (downtown Eugene, Gateway area, Valley River center) ranged from 58 to 75. The middle section of Amazon Creek is heavily affected by impervious surfaces. However, we did not have resources in this assessment to assign an index to each waterway in the study area showing to what degree each reach is influenced by upstream impervious surface.

**Table 17. Acres of impervious surface by major drainage basin (Map 13) by percent impervious surface class.**

| Drainage basin | Acres for each percent impervious surface class | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 to 11.5% | 11.5 to 23.0% | 23.0 to 32.6% | 32.6 to 40.4% | 40.4 to 48.5% | 48.5 to 58.3% | 58.3 to 75.0% |
| *Eugene* | | | | | | | |
| River Road – Santa Clara | 1312 | 4166 | 632 | 2546 | 1363 | 302 | *102* |
| Bethel – Danebo | 2422 | 1816 | 1392 | 1091 | 1520 | 797 | *267* |
| Willow Creek | 1422 | 867 | 247 | 0 | 0 | 31 | *0* |
| Willamette River | 685 | 3367 | 121 | 501 | 411 | 895 | *570* |
| Willakenzie | 1599 | 565 | 821 | 1144 | 2128 | 812 | *223* |
| Amazon | 1237 | 2322 | 1646 | 2049 | 2845 | 902 | *112* |
| Ridgeline | 166 | 175 | 119 | 0 | 0 | 0 | *0* |
| Laural Hill | 168 | 309 | 97 | 78 | 0 | 0 | *24* |
| *Total Eugene acres* | *9011* | *13586* | *5073* | *7409* | *8267* | *3740* | *1299* |
| *Springfield* | | | | | | | |
| North Gateway | 127 | 591 | 232 | 123 | 0 | 128 | 0 |
| West Springfield Q Street | 0 | 00 | 272 | 195 | 756 | 654 | 76 |
| Willamette River | 0 | 0 | 45 | 373 | 0 | 0 | 0 |
| Glenwood | 0 | 0 | 0 | 735 | 0 | 0 | 0 |
| Dorris Ranch | 508 | 123 | 0 | 0 | 0 | 0 | 0 |
| W. Spring. Hayden Bridge | 0 | 658 | 540 | 404 | 61 | 0 | 0 |
| Q Street Floodway | 0 | 0 | 0 | 0 | 1789 | 502 | 50 |
| Mill Race | 477 | 343 | 0 | 41 | 368 | 16 | 0 |
| Jasper | 261 | 0 | 312 | 235 | 0 | 0 | 0 |
| Jasper – Natron | 1030 | 1328 | 0 | 87 | 0 | 0 | 0 |
| South Cedar Creek | 683 | 0 | 608 | 271 | 0 | 0 | 0 |
| North Cedar Creek | 1675 | 0 | 0 | 0 | 0 | 0 | 0 |
| Weyerhaeuser outfall | 0 | 0 | 487 | 1238 | 826 | 0 | 0 |
| *Total Springfield acres* | *4760* | *3042* | *2496* | *3702* | *3800* | *1300* | *126* |
| *Study area totals* | *13772* | *16629* | *7569* | *11111* | *12067* | *5040* | *1425* |
| *Study area totals; %* | *21%* | *25%* | *11%* | *16%* | *18%* | *7%* | *2%* |

Increases in peak flow affect fish by increasing velocity and thereby subjecting fish to involuntary downstream movement during runoff periods. Their ability to move back upstreams to their original position may be hampered by small jumps created by culverts and other instream infrastructure. It is also a large expenditure in energy for a fish to move back upstream. When fish are concentrated in downstream reaches of a watershed, food supplies can become scarce or summer water conditions may cause their demise. High-velocity water also impairs the ability of a fish to feed. Increasing water velocity usually decreases the ability of fish to hold a position in the channel and catch the drift floating downstream. The stormwater causing the increases in peak flow is typically turbid and, since most fish are sight-feeders, this decreases their ability to locate food sources.

Increases in peak flow can lead to channel incision in some soil and geology types. This has been noted for the glacial till soils in the Seattle, Washington, area. However, the slopes and soils bounding study area streams are resistant to erosion, bounded mainly by hard clay or highly weathered rock. There is no evidence of channel incision except where the channel was intentionally excavated to increase its capacity.

### 2.2.2 Channel characterization

During late winter and early spring of 2002, the channels of all non-river waters within the study area were characterized. Non-river waterways included mill races, natural and excavated non-river channels, natural and constructed ponds, and sloughs. In some instances where a slough appeared to function more as part of a river system than as a unique non-river channel, it was not included in the non-river data assessment. This is the case for Keizer Slough and Maple Island Slough.

About one-third of the water type reaches within the study area were surveyed in the field. Access limitations prevented the remaining two-thirds from being field surveyed. For these, aerial photos and field observations of upstream and downstream or adjacent reaches were used to assist with the characterization.

Water type reaches were assigned the channel characteristics shown in Table 18a:

**Table 18a. Channel characteristics assigned to each non-river reach.**

| *Parameter* | *Classes* | *Comments* |
|---|---|---|
| Size | Small (< 2 cfs average annual flow)<br>Medium (2-10 cfs average annual flow)<br>Large (> 10 cfs average annual flow) | Using method developed by the Oregon Department of Forestry.<br>Assigned to only waterways, mill races, and sloughs. |
| Channel confinement | Not confined<br>Confined, steep hillslopes<br>Naturally confined, high banks<br>Channel excavated<br>Flood plain filled<br>Bermed | Assigned to only waterways, mill races, and sloughs. |
| Bank material | Natural material<br>Fill<br>Riprap<br>Concrete | Each side characterized for linear water types. Perimeter characterized for ponds. |
| Geology | Basalt hillslope<br>Missoula flood deposit<br>River alluvium | |

In this analysis, linear features such as waterways, mill races, and sloughs are reported in terms of length of channel. For ponds, the perimeter is reported.

The total length of artificially confined waterways in the study area was greater than the total length of waterways that were not artificially confined (Figure 13 and Map 4). Mill races and sloughs were a minor component of the total length of linear water types. The summed perimeter of all ponds was 53 miles, with about one-half being gravel pit ponds.